THE HUMAN MECHANISM THE MOST MARVELLOUS

READ BEFORE SECTION III OF THE ROYAL SOCIETY OF CANADA AT ITS MAY MEETING OTTAWA 1901.

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So wrote Dr. Lardner in his "Animal Physics" some 40 years ago.

To be read by C. Baillairgé before section III of the Royal Society of Canada at its May meeting 1901.

Yes, the human mechanism made up, as it is, of some 200 bones or rigid components and of more than 500 muscles—flexors and extensors, and thus comparable to so many springs—with elastic ligamentous media between the two ; is indeed the most prolific of every kind or degree of motion and action ; and in any and every direction is it adaptable to the most varied and varying circumstances. It is Universal. And the eye is there to oversee, the head to direct it in all its doings, in its multifarious functions, its displacements, its travelings.

It comprises within itself every known or conceivable mechanical device, motion and combination of motions and it is adequate to perform any and every duty which future discoveries, inventions, industries may require of it—in the same way as the possible combinations of which the traits of the human physiognomy are made up, explain the non resemblances of the human race since the creation of man, and are in number sufficient to provide for like differences for all time to come.

The human machine ministers to all its own requirements : supplies itself with the food fuel which becomes elaborated into the life sustaining, life repairing fluid which gives it power ; as does steam to the steam engine—wind and water to the world at large.

It is its own lubricator, having constantly on hand at all its joints, articulations or rubbing surfaces, the synovia which the system is as constantly secreting to keep up the supply.

It is its own caretaker, cleanser, scavenger : getting rid of its waste products, eliminating them from the system—while the duplex pumping mechanism of the heart, after forcing the arterial fluid to the remotest ramifications of the body, whence it returns by the veins to the heart again, sends it off anew on its way to the

septic apparatus of the lungs, where it becomes revivified ; and during this process of cremation of impurities, it is, that the combination of the oxygen of the air taken in in breathing with the carbon of the blood, creates the heat which keeps up the temperature necessary to the maintenance of the working pressure of which the machine is capable and in need of.

The human machine is a most perfect "automobile", capable of performing all the duties assignable to that piece of machinery which in industrial processes is called a "traveller"; while the "crab" or sub traveller which crawls back and forth over this, is exemplified in the far stretching arms, outriggers or "crane" like features of the body.

The human mechanism is also the more perfect in that it endures the longer, due to the self repairing faculties already alluded to. It requires repose, but in the long run can beat and wear out the more powerful horse or other beast of burden, and like the engines in our ocean steamers, keep at it for days in succession or until exhausted from sheer want of food or fuel ; and if no one man machine can of itself move or manipulate heavy weights, it can do so by association with others of the kind or by multiplication, in the same way as it requires a nest of furnaces or fires side by side to raise the steam to drive the liner, or as in the erection of the pyramids of by gone days.

The osseous and muscular systems of the human mechanism, the sinews, the mode of articulation of the several parts, their juxtaposition and ligaments, the nature of the separating media, render it capable, as said, of motion in every direction and it can as with the "trip hammer" in the forge, act with the utmost delicacy and caution, as with the greatest velocity and energy.

When the work to be performed cannot conveniently be placed to suit the machine, the latter can go about and accommodate itself to every possible position it may be called on to operate in, as above, below or to either side of the thing in hand—or, while other pieces of machinery have to be transported by extraneous force, hoisted or lowered to where their ministry is required ; the human machine can by its own inherent strength and power of locomotion, ascend, descend and move in any direction towards the very point where, what is required of it is to be accomplished : a "traveler" as said before.

The human machine can by perambulation one of the motions of which it is capable, measure distances by pacing, while the clock-work of the mind can register, and run up the same, multiply, divide, substract, and the hand make a visible and imperishable record thereof on paper or its equivalent.

From time immemorial there have been used the "foot", the "hand", the "finger"—its articulated parts answering as sub units or fractions in the process ; the "cubit" or length from elbow to tip or extremity of middle finger ; the "fathom" or distance to which a man can extend the tips of the middle fingers of the outstreched arms and hands as in the measurement of ropes and cables and of sounding lines, etc., the "span" from tip to tip of thumb and finger as in embracing the octave on a piano.

It can as well make measurements on a smaller and even the most minute of scales : for where the machine under consideration can supply no smaller standard of comparison than the thickness of a finger nail or a hair's breadth, the measuring can be arrived at indirectly, as in getting at the thickness of a sheet of paper by piling sheet upon sheet to the depth of the known fraction of an inch and then dividing as required, or as with gold leaf in comparing areas of the beaten leaf and unbeaten ingot ; or again in arriving at the size of the invisible or micrometric platinum wire which has been made so by gilding, pulling and melting off the envelope.

And as well can our human mechanism measure and compute in time as in extent. It can appreciate seconds and compute the velocity of a running stream and height of fall with a view to its horse power. It can appreciate tenths of seconds and hundreths and even minuter fractions of time by causing to pass between the thumb and fore finger during one second of time, the successive leaves of a book of 100 or 1000 folios.

The human machine is therefore capable of performing the duties both of a chronometer or measurer of time and of a measurer of distances as of a "foot rule" or other standard of extent.

And now that we have taken this general view of the human mechanism and its capabilities ; let us review it in some detail. The eye for instance observes all things ; it is fitted to the penetration of space, taking in, as does the telescope, the satellites of Jupiter, the phases of Venus. It can adapt itself to every degree

of light, as well to darkness the most impenetrable. Even with the head immovable, it embraces a cone of observation of an angular extent of nearly 90° at the apex ; while, when the head itself is turned, which in virtue of the elastic medium uniting the cervical vertebræ, it can do, like unto the motion of a telescope on a "ball and socket" pivot or support ; the eye can be made to sweep the whole visible hemisphere, including the zenith and the nadir and even more than a hemisphere, when at a height above the earth's surface or from a balloon or mountain elevation.

The eye can expand or dilate, contract or shrink, changing by degrees in a way to prevent the effects of too sudden a transition from light to darkness or the cuntrary ; and in the same way as do the lungs and chest and in fact the whole system in ascending in a balloon and again descending, suit themselves to the varying pressure of the atmosphere ; or in passing through an air-lock from the normal pressure of the air to a pressure many times as great, or form greater to less as in the execution of foundation works under water and in tunneling.

These provisions in the animal structure, or human machine, may be assimilated to the springs and buffers in railway trains or more correctly to those of the Westinghouse or air break ; and thus can the human machine like any other piece of mechanism, work under varying stresses without shock or inconvenience to itself.

Every one must have noticed with almost stupefaction the variety of motion and adaptation of the mouth to the diverse requirements of articulation, mastication, elimination of what is to be rejected ; as in the throttling of the lips in the act of whistling, the discrimination between bone and flesh in feeding, the complex action of the teeth and lips and tongue in fereting out the tiniest of fish bones, the minutest particle of gritty matter—the action of the cheeks at playing on a wind instrument or in blowing ; their contraction on inhaling the contained air, thereby creating a vacuum against which the outer air reacts in pressing forward both liquid and solid food into the cavity and toward the throat where the uvula, the while, acting as a " throttle valve " in closing the glottis or upper extremity of the larynx leading to the lungs, causes the food to pass along toward the œsophagus leading to the stomach, without the danger of its going the wrong way—the same action of the uvula recurring, during regurgitation, in pre-

venting foreign matter from entering the trachea and causing coughing or convulsions as occasionally occurs. Here then have we illustrations of the "plenum" and the "vacuum" and the action of the uvula is like unto the "slide valve" of a steam or air or gas engine, in alternately closing one port while the steam or other pressure-bearing fluid is entering the other.

In the teeth we have "cutters" : the incisors ; "tearers"; the canines ; " grinders " : the molars ; and this grinding action is brought about, as more noticeable in ruminants, by the lateral, motion or see-saw action of the lower jaw which is articulated to the base of the scull in a way to allow of both lateral and vertical displacement. This peculiar mode of fastening may be noticed in the carving of a calf's head at dinner.

The teeth when brought together can also be made to perform the duties of a "strainer" either on taking in or expelling the liquids of a food while repelling or retaining the more solid portions ; and how the Chinese can use the mouth as a "sprinkler" of clothes preparatory to ironing or mangling, we have all noticed more than once.

The jaws and teeth also form or are capable of acting as a powerful "vice" or "clutch" in holding together, tightening, squeezing, crushing or breaking ; and thus acting as " pincers ", " tongs " " nut crackers, " etc.

The tongue can reach and search the space between the teeth and cheeks—but the most beautiful adaptation of which the lips, teeth, tongue and cheeks etc. are capable is in the articulation of sounds of all kinds from the larynx, their modification in tone and pitch, etc.

The many variations to which the component features of the face may give rise, every one has noticed in play acting, pantomime, the personification of character ; but what we are here more directly concerned with are the mechanical features and motions of the face as a component of the human mechanism. That the cheeks, lips, nose, forehead, eye lids, the jaws and chin though in a less degree are all susceptible of enough motion, to perform the useful function of knitting or twitching in a manner to drive away, if not all the pests, at least the domestic fly and thus save us from the necessity of constantly interrupting our work to raise the hand to eliminate the nuisance.

And we have seen how the human machine is a "self-feeder" and can and does prepare its own food fuel, reducing it and grinding into proper size to reach the stomach and then become elaborated into chyme and chyle and pass therefrom into the intestines whence to go forth on their mission of blood and tissue making and repairing, wherewith to fortify the muscles in their assigned functions of protectors to the osseous system from shocks and accidents in case of collision with external forces.

Passing on now to a consideration of the more truly mechanical or machine like functions of the human frame—we have already noticed the almost "ball and stocket" motion of the head, due to the elasticity of the ligaments separating while at the same time uniting the cervical vertebræ, and thus allowing the head such scope, play or action about its centre of support.

Now the whole spine or all the dorsal and lumbar vertebræ thereof, are separated by these same cushions of elastic or compressible and extensible substance ; and the whole vertebral column, the whole body or machine can thus sway to and fro in all directions, and even to some extent, absolutely twist around as on a pivot, though of course a portion of this rotation is due to the revolving the fibula of the lower leg about the larger bone (the tibia) in the same way as the fore arm revolves partly about the humerus by the motion of the radius around the ulna.

See also the action of the leg and foot at working the *treadle* of a spinning wheel, or lathe, or sewing machine or saw etc., or the *pedals* of a piano while the hands are at work elsewhere and at quite a different species of mechanical action.

See again the arm or arms in gesticulating during a speech or sermon or in gymnastic exercise, where the fore arm can act at its hinge joint at elbow, as well the leg about the knee articulation, and how the whole arm can swing in a circle and in fact throughout every point in fully more than a hemisphere in virtue of its so called ball and socket or universal joint at the shoulder ; while the leg can follow suit in space by the similarly constituted revolving joint at the hip.

It is absolutely beyond the ken of our intelligence to conceive, our capacity to describe the infinity, so to say, of positions and motions of which the several parts of the human machine are susceptible. Look at a man picking, shoveling, hammering,

pumping, working, a windlass, a capstan ; his swinging motion in handling a scythe, in felling a tree, heaving at a crane, pulling, pushing.

He can work sitting, kneeling or standing. He plies the pick while in a horizontal position, at a narrow seam of coal between two strata of stone in a coal mine.

Look at him in the handling of an auger which he can work, as in ship building, in every imaginable direction. See him handle a sledge, an axe, a crow-bar or pry or lever, the adze, the plane, the scraper, the brush or broom.

Look at his varied attitudes in the act of dressing, at his contortions in endeavouring to get into a shirt and button it at the collar from behind See him box and kick and wrestle; walk, run, jump and hop—watch him handle a musket, sword, lance, bayonet. a stick, a sling, a bow and arrow —See him again at criket, hockey, hurley, la crosse, golf, lawn tennis, ball—at skating, whirling, sliding, ploughing, seeding, reaping, rowing, curling, quoiting, swimming, bicycling, —the *catapult* action as in throwing, see him bowing, hodding up—and down a ladder, weighing anchor, climbing a pole or rope where his legs are twisted around it below and in opposite directions to prevent slipping while the hands push upward for another grip.

See how in shoveling, every portion of the body may and does in turn become a fulcrum according as the implement is long or short handled, and according also as he must move the material from a low or medium or a higher level and throw it down or up or horizontally, and accordingly again as he has to use the body—knee, thigh, abdomen, stomach or shoulder to thrust the shovel forward, where the material is so compact as to require it.

See how in ditching or trenching he uses the foot and pressure of the body to force the spade into the soil and then, how the back of spade is made to react against the as yet unexcavated portion as a fulcrum and thus becomes a *lever of the first kind*, where the power is at one end, the load at the other, and the fulcrum between the two ; while so soon as the spade is charged or loaded, the fulcrum and power change places, the *lever* becoming one *of the third kind* where the fulcrum is at the inner end, the load at the outer and the power for lifting at the center or between the two first ; while again when he plies a crow-bar to lift or move a

stone or heavy weight, he drives the bar in under the thing to be moved or lifted, the *lever* becoming in this case one of *the second kind* where the weight is between the fulcrum and the power.

Now come we to the beautiful mechanism of the hand : this of itself the most complex and universal piece of machinery. There is no end to the multifarious uses to which it can be applied. You can take a *pinch* of any substance as between the forefinger and the thumb, or increase the pinch by using with the thumb two, three or the four fingers—a hand full, or hold your hand palm up and make a *scoop* of it—turn it the other way and use it as a *scraper* or after sewing seeds, use the opened fingers as a *rake*, the thumb and finger the while or at intervals performing the duty of a *crusher* of the larger or coarser sods or lumps.

Close your fingers and they will hold water while you *scoop* it up to drink from as on a survey or a pic-nic. Again with the thumb and finger you can *knot* the end of a piece of thread or twine or tie two ends together—thread a needle, push the needle half-way through the material to be sewed, catch it on the other side and pull it through the balance of the way.

Look at the simultaneous action of all the fingers at playing a piano, a flute or any stringed instrument, or one with keys—work the type-writer—look at your hand in writing, drawing, painting, weeding, plucking fruit or berries.

See the freedom of motion of the hand about the wrist due to the same play between the carpals and their ligaments, as of the tarsals of the foot already noticed. The hand can, as the whole arm at the shoulder, describe quite a circle and can make a perfect one, as in free hand drawing when the fore arm and a fortiori the whole arm is enlisted in the process.

See the strength of the hand and fingers in handling heavy weights ; the cramping, vise-like action of the thumb and fingers in holding, by mere force of friction such a weight as it can bear. Why, the very finger ends and nails can catch and hold and handle a barrel or a firkin by the edges of its hoops.

You can finger out the single handed alphabet for the dumb and separate the fingers into two's, or into one and three and working from either side—bend all the fingers or any one or more of them either at the knuckles or at the articulation between the

first and second phalanges or both and again the outer phalanges and all of them in closing your hand till it becomes a fist.

We had almost failed to notice the pretty action of the thumb and fore finger in the act of buttoning, unbuttoning, and there are a thousand other actions the human hand or hand and arm is or are adequate to as in the *boomerang* action of spinning a top and bringing it back to the very hand that thrust it into space, of the *hammer* like thump of one's fist as with the knuckles in boxing, the side fist in driving in a cork, etc ; or in crushing anything, the *wrench* like action of the hand in uncorking or unstoppering ; winding a watch, unscrewing or the contrary.

Have you ever thought of how, while holding your cigar between the thumb and finger, you can utilize the little finger in brushing away the ash, and see how the thumb can in turn be made to meet any and every of the fingers and at any point of their three phalanges. See how the hand will bend in the direction of its length to allow you to get it through the cuff of your shirt if buttoned in advance, and if not too big or stiff, force it through the shackle called a handcuff in police phraseology. See the graceful curvature of the hand of the artist at piano playing, its double curvature–convex at the wrist or carpals, concave at the phalanges and how the hand could bend also laterally and in fact accommodate itself to anything and every thing.

And now when both hands are brought into play, see the beautiful interlocking of the fingers and in so many ways, to form a *scoop*, a *seat*, a *support*, a *clasp* as in holding an armful of wood—bringing the hands side by side to dip up water and drink from, to throw, to bail out a boat when no ustensil is at hand.

See how in washing the hands either of them can be made to turn and twist around the other, or about one and any one or more of the fingers at a time the double motion of the hands, and and in opposite directions in the winding of a watch or while wringing the surplus water from a towel, etc, and as accelerative of the drying process.

See how the provision of an elastic medium between or at the articulations of all the phalanges or component portions of the fingers, as well between the carpal or wrist bones allows of a motion like those of the components of the vertebral column or in all directions—and inclusive in the trunk and limbs and vertebræ

of the all important provision for compression, in the way of *springs* or *buffers* between the bones by which one breaks one's fall in jumping from a height which otherwise would bring the bones into contact and shatter them or dislocate the osseous structure.

Was there ever a more striking representative of the *splice* between the ends of hempen ropes, or the wires of a cable, than that which after locking the hands with interwoven fingers, you obtain by overlapping them and then twisting the hands in opposite directions—Try that; it is admirable, and if tightly clenched, they can resist all your own strength or that of any one else at pulling them asunder.

Gymnasts and athletes exemplify these motions to a greater extent in their varied somersaults and contortions, and there is no piece of mechanism or machinery capable of anything of the kind, except and only to some extent, a coil of tempered wire used as a *door spring* which, when the door is opened, returns it to its previous position —the abductor muscles of the body also returning it to its normal state after it has been so disturbed by an undue stretch of the flexors and extensors.

The human frame may conform itself to the functions of a *foot stool* or *step ladder* or sort of *scaffolding* to work from or from which one can reach to a greater height, as in climbing ; by bending the body or folding the machine upon itself in a way that a first step may be taken on the knee or calf, whence to reach the back and thence the shoulders, and the head if needs be ; the folded machine, the while, opening itself out to full height. Pyramids of three to five men in height are thus formed with comparative facility by acrobats.

As a *post* or *column*, man in his erect state, is very powerful ; carrying, as he can thus do, many times his own weight resting on his shoulders—He can bear a tremendous stress upon his knees, while in the sitting position ; but where he makes proof of almost superhuman strength, is in the lifting on his back of a thousand pounds or more from off two trestles between which he is reclining forwards with his hands resting on a chair or other point of support of proper height. This he does by merely straightening up his arms and legs, and thus bringing into play the immense effort one can exert at the knee and elbow articulations, as with the so called *toggle joint* which works the ponderous jaws of the machine known as a *stone-crusher*.

This action of the *toggle joint*, any one can exemplify for himself and bear witness to, as in ascending a flight of stairs or in fact only one stair of the flight : by raising one foot on to it, and then bending forward to bring the centre of gravity of the body over the new point of support, raise the remainder of the body to the required elevation by merely straightening the leg or bringing the knee articulation into play and without any effort of the other leg to do the lifting.

Man can again support himself as a *rigid beam* or *bridge*, in a horizontal position, with nothing but his head and toes resting on two chairs or other points of support, by thus stiffening his system ad libitum ; and again, see his immense strength. *his rigidity of structure* when stretched *horizontally upon a ladder*, a clinging with feet and hands to two of the rungs, or rather pulling with the one, and pushing with the other, while a horse or pair of horses vainly endeavours to dislodge him.

And due to this same powerful action of the muscles at the knee and elbow, a man will, either in the sitting, standing or crouching position, exert great effort, when well supported from behind, in forcing in a door, keeping an enemy at bay, etc ; as, with his back, when supported from in front: he can produce a like effect.

This action of the hinge joints of the human machine, occurring as it does at the knee and elbow, is illustrative of an almost paradoxical case in mechanics, as where it requires an infinite force, acting in the direction of the *length of a string or chain or beam* horizontally stretched and thus subject to the effect of gravity, to bring it into a mathematically straight line, while of course, it similarly requires a minimum or absolutely inappreciable effort when applied at right angles thereto to bring it into line or cause it to deviate therefrom.

The body, also when slightly sloped or bent forward is capable of great exertion in rectifying or straightening itself up under a heavy load upon the shoulder, thus showing the power of the hip-joint and vertebral column in assuming a rectilineal direction, under a weight of as much as almost half a ton or more.

See now the powerful leverage exercised by the tarsal bones and muscles of the foot, when a man in the sitting posture with almost any weight upon his knees, can raise them by as many inches as

the foot will allow of-and in the same way, when standing or upright, the human frame, can by the tarsal action of the foot or feet raise itself and without effort, and with the heaviest weight upon the shoulders, to a height several inches above the normal.

The great strength of even one of the toes, the greater or big toe, is fully exemplified in the ballet daneer who can twirl around upon tip toe, though of course the very velocity of the motion causes a centrifugal action which tends to diminish the weight upon this last articulation, of the pedal member ; and this is analogous to the additional capacity which a man acquires for leaping or somersaulting, after starting for it from a distance on the run ; in the same way as certain birds that can not rise to winged flight without this, and, as of a flying machine which is also benefited by a run along the ground before it acquires the speed or momentum necessary for the effort of rising into space : all of which are but examples of how centripetal action is or can be nullified or overcome by a velocity sufficient to give the necessary centrifugal or counteracting force

See how you can spread the feet laterally until almost into line or heel to heel, and again in the contrary direction or toe to toe, and how, when at right angles to each other, they embrace or enclose between them or within themselves the greatest area of base to stand on and thus bring the *centre of gravity* of the system into a position of stable equilibrium—and was there ever a lovelier reversed curve than that formed by a well made foot, and to all degrees of curvature, by the arching of the tarsals upwards and the corresponding lowering or curving downwards of the phalanges of the toes into the appearance or form of an *invert* ; a concave or inverted arch : together an *ogee* curve.

And now that we have seen the action of the system as a whole–if we come to consider that of the separate or component parts thereof, - the diversified or differential, while at the same time simultaneous action of the several members which as the arms, hands, legs and feet can act in pairs or individually ; we will marvel at their apparent endlesness. We have for instance, while standing on one leg, the action of the other at kicking as at foot ball, or as a stay or strut when in sawing wood one leg is used to steady the log, or one knee raised and resting on a board or bench to hold it fast while ripping ; illustrating thus the action of a *clamp* or *vise*.

Notice again the delicacy of touch with which the finger tips are endowed as in artificial flowers making, in lace-making ans microscopic type setting, in hair work and embroidery —and now the double-hand dumb alphabet, sharpenning a pencil, manipulating a pair of scissors on a razor See the watch-maker in his more than tiny undertakings, the jeweller, the surgeon in his ligaturing of veins and arteries, etc.

See how the hands and arms can and do work together in throwing bricks in twos and threes and fours at a time in a way to keep them together on their journey till another seizes hold of them.

In a word the human machine is equal to all the industries of life, to any and every of its requirements and has been from the beginning of time and will ever continue to be and in all climes and under every variety of temperature, weather, surroundings and circumstances. It can handle and manipulate itself. Its outriggers, the arms can reach to every part of the system excepting may be a narrow portion along the dorsal vertebrae of the spine, and here you have to fall back on the device of a rubbing post which elicits the ejaculation : "God bless the duke of Argyle."

The human machine can (cat like) elongate itself in a way to get through a very narrow aperture. It can actually crawl like a reptile or a worm by a species of peristaltic action of the body, where the abdomen if prominent can be drawn in, by forcing up the viscera into the thoracic cavity, the oblique motion of the ribs in breathing favoring the motion forward or backward as the case may be ; and in the same way to some extent as a worm or caterpillar can curtail, gather up, or shorten its body, then stretching forward at its foremost end pull up the rear, or in the contrary direction, the feet and hands the while serving alternately as fulcra from which to push and pull, as with elbows, knees and feet and hands in crawling through a pipe or sewer or as need may be, in thrusting one or both arms forward to diminish the impeding breadth at the shoulders, or again with one arm ahead, the other, normal to the body.

We have spoken of man or the human mechanism in the standing, sitting, kneeling posture, but there is also the squatting on one's heels and knees or directly on the floor or ground, the legs apart sufficiently to allow of it, or the legs akimbo or

crossed under one, tailor like, or with legs extended, or one of them extended and the other folded under.

See man in what is called the tug of war, how his fulcrum is the very ground he stands on and against which he reacts by mere friction of the surface, with body leaning as far as possible towards the horizontal.

There are other actions of the human machine where its variety of adaptation to everything that is required to be done is made apparent, as where he will sometimes in the absence of an implement for the purpose, break a piece of wood resting on one or two points of support by jumping up and then coming down upon it with the whole heft of the body, or thus bend a piece of iron, or stamp down and consolidate earth or snow to reduce it to less bulk, thus acting as a *beetle*, or a *rammer* or a *pounder ;* or he will while standing on one leg, lift the other and break a wooden bar across his knee or so bend an iron one.

See how a man can keep his perpendicular on the deck of a surging vessel. He can on a horse or charger, guide him with one hand, spur him into action with his feet while wielding the sword or javelin with the other ; and one need not be reminded of all that a man can do as an acrobat, a contortionist, a mimic of men and animals. He can *dive* into deep water, *climb* a mountain or a tree, thus bringing into play all his energies and in turn every component of the human mechanism.

Again there is not a motion or act imaginable but what he is capable of, and without entering into a consideration of his chemical laboratory, the stomach and the phenomena of digestion, the elaboration of his life giving and sustaining fluids which pertain more directly to the domain of Physiology to treat of ; it may be said, that his vascular system is absolutely akin to *an aqueduct*, delivering as it does, not by gravitation but by *pumpage*, from a central station the pure or arterial fluid to every portion of the system, the most remote from the heart, the most minute, and on return of this by *drainage* towards the heart again after it has left its vivifying elements behind it and has become polluted with foul matter, it is sent away on its mission of purification to the lungs as already slated and where by endosmose and exosmose it undergoes a process of *filtration*, as does water through a bed of sand, leaving its impurities, or bacteria behind it. And it posses-

ses its own *telegraphic system*, the central station at the brain, the nerves *the wires* of the system.

It would require a volume and many volumes to set forth in detail all the actions, all the motions simple and compound of which the human mechanism is capable, and even then there would remain an endless variety of functions to narrate : for lived one for a thousand years or ten thousand or for all time to come and went we on in the march of progress and invention even as we have done during the marvelous 19th century which has just closed upon us, it would be found that the human make up is as surely competent to the task of representing it within itself as it has been in the past, every new industry to come finding in it an adept at its manipulation.

The human system embodies within itself and is an exponent of every scientific discovery since the beginning of time. We have already noticed its telegraphic capabilities between mind and body and to every part thereof, the most minute, the most remote, through the wiring instrumentality of the nerves. The least thing manifests and evokes its inherent electricity, as when combing or brushing the hair, sharpening a pencil, when you have the chippings adhering to your fingers ; gliding over a carpet, when on presenting the knuckle to any object, be it of metal or almost any other, the human body included, or that of any animal, you have a tiny spark passing from the one to the other.

Isolate a man and by friction and threshing of him with certain exciters of electricity, as with the skins of felines ; you can make a leyden-jar of him, an accumulator, a storage battery and a dynamo giving off the fluid as required.

The hypnotist illustrates in us the results of wireless telegraphy and how without any contact or any direct communication between persons, one man's mind evokes a repetition of the workings within that of the other, and that, at distances apart as far as one can see or even beyond one's ken in certain cases.

We illustrate photography where the picture is taken in the camera chamber of the eye and recorded on the retina —telephony, when speaking at or to a distance accentuated by the directing instrumentality of a speaking trumpet—phonography, when storing in the mind, engraving on the brain every word and sound capable of reaching it through the ear and auditory nerves ;

but while in phonography a separate disk is required for every speech or air or record of a lecture, the recording in the brain is all done on one and the same disk or set of disks, (if the inner layers of the brain cells duplicate the outer,) whence they are or can be, under the name of memory, evoked, brought forth, disentangled from all others in obedience to the will and paraded again before one, and made sensible to the eye.

The speech, the spoken words, the tune or air or sounds can be repeated, rehearsed, vocalized, given expression to by our vocal organs ; and thus man is comparable to a *graphophone*. He draws again upon his memory for the reproduction of the image of anything he has seen ; he sees it in motion as he did yesterday or years ago and thus illustrates within himself the *kinematograph* and he draws forth from his storage in or on the brain or on the registry office of the ear, the accompanying sounds ; and in advance of the coming machine : the *phonokinematograph*, he illustrates within himself this still to be invented mechanism which will not only show us things in motion ; but with the accompanying sounds and noises —We shall not only see things pass before us ; but shall hear the noises, voices—see the lighting and hear the thunder, see the dust and hear the wind, see the fire and hear its crackle or its roar.